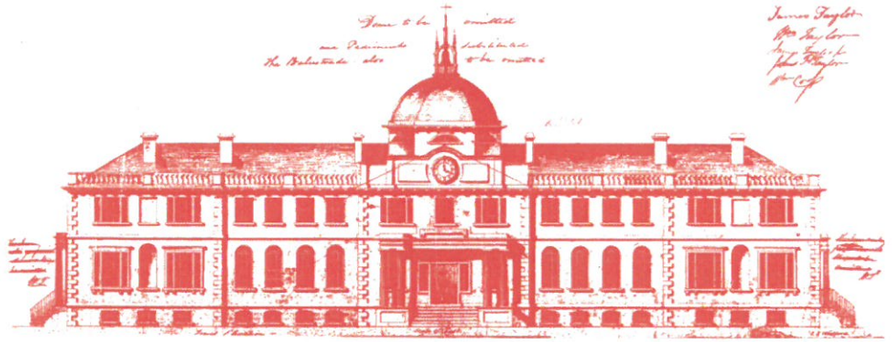
Atlantic salmon (Salmo salar) Migrations in a Large Hydropower Reservoir and the Regulated Saint John River

Abstract

My research focused on evaluating the impacts of the large Mactaquac Generating Station (MGS) reservoir on the migrations of the endangered Outer Bay of Fundy Atlantic salmon (*Salmo salar*). Salmon respond to flowing waters to determine the direction, timing, and speed of their migrations. A large reach of the Saint John River (SJR) was impounded by the MGS in 1968, transforming the habitat from a free-flowing river to a lacustrine environment with altered and slower flow. I examined all migratory lifestages of Atlantic salmon in the SJR using acoustic telemetry, including pre-smolts, smolts, adults, and post-spawned adults (kelts), as they navigated these environments.

Migration rates were compared between the lentic MGS reservoir and the more lotic reaches upriver and downriver of the MGS to assess whether migration is delayed in the reservoir. Nearly all of the tagged salmon experienced migratory delay within the reservoir (medians: smolts 1.3-6.4 d, kelts 3.5-10.5 d, adults 1.5-5.7 d) due to suppressed migration rates (medians: smolts 5.0-13.3 km d^{-1} vs. 15.4-29.3 km d^{-1}, kelts 4.4-8.9 km d^{-1} vs. 14.9-36.8 km d^{-1}, adults 8.5-20.1 km d^{-1} vs. 19.3-46.9 km d^{-1}). Migration success through the reservoir was higher for downstream migrants (smolts and kelts > 80 %) than upstream migrants (adults < 50 %).

Recommendations informed by these findings with the aim of aiding recovery of this endangered population are given to hydropower and fisheries managers, including: *i*) changing the spill regime to allow a greater proportion of downstream migrants the option of spillway passage since all but a few smolts and even the earlier kelt migrants were sometimes forced to pass via turbines; *ii*) constructing a downstream surface-bypass facility which is more economically feasible than increasing spill and is supported by the observed variable passage timing; *iii*) allowing the free-swim of downstream migrants through bypasses in comparison to a trap-and-haul strategy that was not found to increase survival of smolts; and *iv*) maintaining trap-and-haul operations for adults migrating upstream of the MGS due to the high proportion of fallbacks and increased energy expenditure from superfluous movements in the reversed direction to the intended migration observed in the reservoir.



Home of the School of Graduate Studies, Sir Howard Douglas Hall was designed by J.E. Woolford in 1825 and is the oldest university building in Canada still in use.

The University of New Brunswick recognizes that the university sits on traditional Wolastoqey territory. The river that runs right by our university – the Saint John River – is also known as Wolastoq, along which live the Wolastoqiyik -- the people of the beautiful and bountiful river.

UNIVERSITY OF NEW BRUNSWICK
SCHOOL OF GRADUATE STUDIES

ORAL EXAMINATION

Amanda Babin

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

Ph.D. Candidate

Amanda Babin

Graduate Academic Unit

Biology

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December 17, 2019

1:00 p.m.

Loring Bailey Hall
Common Room 27

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Examining Board:
Dr. René Malenfant (Biology)
Dr. Allen Curry (Biology)
Dr. Paul Arp (Forestry & Environmental Mgt.)
Dr. Tommi Linnansaari (Biology) Supervisor
Dr. Stephan Peake (Biology) Supervisor

External Examiner:
Dr. Joseph Zydlewski
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USGS
University of Maine

The Oral Examination will be chaired by:
Dr. Kevin Englehart, Associate Dean of Graduate Studies

BIOGRAPHY

Universities attended (with dates & degrees obtained):

2014 – present	PhD candidate, University of New Brunswick
2011 – 2013	MSc in Biology, University of New Brunswick
2012	SeaBASS (Bioacoustic Summer School), Pennsylvania State University, PA Funded Participant, competitively selected
2012	Diploma in University Teaching, University of New Brunswick Saint John
2009	BSc in Biology (Honours), Mount Allison University, Sackville, NB

Publications:

Babin, A., Linnansaari, T., Peake, S., Curry, R.A., Gautreau, M., and Jones, R. 2016. Evaluation of two alternative by-pass strategies for pre-smolt Atlantic salmon (*Salmo salar*) in the Tobique-Narrows Dam to maximize survival at the mouth of the Saint John River. Mactaquac Aquatic Ecosystem Study Report Series 2016-040. Canadian Rivers Institute, University of New Brunswick, 22 p.

Babin, A. 2015. Methods paper: Atlantic Salmon Smolt and Adult Movements. Mactaquac Aquatic Ecosystem Study Report Series 2015-013. Canadian Rivers Institute, University of New Brunswick, 13 p.

E. Trippel, I.A.E. Butts, **A. Babin**, S. Neil, N. Feindel, T.J. Benfey. 2014. Effects of reproduction on growth and survival in Atlantic cod, *Gadus morhua*, assessed by comparison to triploids. Journal of Experimental Marine Biology and Ecology, 451: 35-43.

Mackenzie, A.B. 2012. Biological Synopsis of the Compound Sea Squirt *Diplosoma listerianum*. Can. Man. Rep. Fish. Aquat. Sci. no. 2966

Mackenzie, A.B. 2012. Biological Synopsis of the Light Bulb Tunicate *Clavelina lepadiformis*. Can. Man. Rep. Fish. Aquat. Sci. no. 2967

Mackenzie, A.B. 2012. Biological Synopsis of the European Sea Squirt *Ascidiella aspersa*. Can. Man. Rep. Fish. Aquat. Sci. no. 2968

Mackenzie, A.B., Babin, K., and Hood, C. 2012. Ghost Fishing Gear Report. Fundy North Fishermen's Association, Species at Risk Habitat Stewardship Program 2011HSP6086.

Mackenzie, A.B., Babin, K., and Hood, C. 2011. Right Whale Entanglement Report. Fundy North Fishermen's Association, Species at Risk Habitat Stewardship Program 2010HSP5510.

Selected Conference Presentations:

Atlantic Salmon Ecosystems Forum, Quebec City, QC. 2019. Atlantic salmon (*Salmo salar*) pre-smolt and smolt movements in the Saint John River and Mactaquac reservoir.

Departmental Seminar, University of New Brunswick, Fredericton, NB. 2018. River to lake: Challenges for Atlantic salmon (*Salmo salar*) migrations in the Mactaquac Reservoir.

Mactaquac Biodiversity Facility update, Fredericton, NB. 2018. Atlantic salmon (*Salmo salar*) in the Wolastoq/Saint John River and Mactaquac Reservoir.

Saint John River Watershed International Cross-Boundary Summit, online webinar. 2018. Atlantic salmon (*Salmo salar*) migrations in the large reservoir of the Mactaquac Generating Station.

25th annual Graduate Research Conference, University of New Brunswick, Fredericton, NB. 2018. Atlantic salmon (*Salmo salar*) migrations in the large reservoir of the Mactaquac Generating Station.

Atlantic Salmon Ecosystems Forum, University of Marine, Orono, ME. 2018. Post-spawned Atlantic salmon overwinter behaviour and spring migration in relation to the large reservoir of the Mactaquac Generating Station. **Several other Conference Presentations**